EXPO
engineering ▲ design

University of Idaho
College of Engineering

IDAHO CSC

REAR-DRIVEN SNOWMOBILE

SPONSORED BY: UICSC
CAPSTONE TEAM: SKIDADDLE

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- Thomas Entwit
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OVERVIEW

- Objective
- Value Proposition
- Background
- Product Requirements
- Concepts and Early Design
- Final Design
- Manufacturing
- Future Validation Plan
- Recommendations

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OBJECTIVE

Design a powertrain and suspension for a Rear-Drive snowmobile, that can directly test against conventional forward drive

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VALUE PROPOSITION

In Short:

- The value to industry will be data showing the validity of rear drive vs. forward drive
- The value to the UICSC team will be an innovative project to bring to competition

Modern Snowmobiles have a track which is turned/driven with cog-drivers in the front. This pushes the track, which being a flexible element, bunches up. This leads to both drivetrain and handling inefficiency. A solution is to pull the track, by having the drivers in the rear. Currently, there are no rear driven snowmobiles on the market as an OEM or Aftermarket platform.

At the SAE Clean Snowmobile Challenge (CSC) which the U of I CSC Team competes in every year, technical innovation is highly valued.

To meet both these challenges, the goal is to develop a rear driven snowmobile system that will be able to directly generate data to compare rear-driven and traditional drive technologies. Our team is proposing a swappable front to rear drive system for this year's CSC team and snowmobile.

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BACKGROUND

- Snowmobiles have plastic “drivers” that mesh into a rubber track to move the vehicle
- These drivers are located towards the front of the vehicle, just behind the engine
- When turned by the engine, the drivers push the bottom of the track in compression
- Can lead to the track bunching up, due to the track being a flexible element
- A solution is to pull the track, by having the drivers in the rear.
- Currently, there are no rear driven snowmobiles on the market as an OEM or aftermarket platform

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PRODUCT REQUIREMENTS

- Create a functioning snowmobile drivetrain and suspension
- Be configurable in both front and rear drive to provide data that is an “apples to apples” comparison
- Handle up to 165 horsepower and 100 Ft-Lbs of Torque at over 100mph
- Retain OEM-level suspension quality

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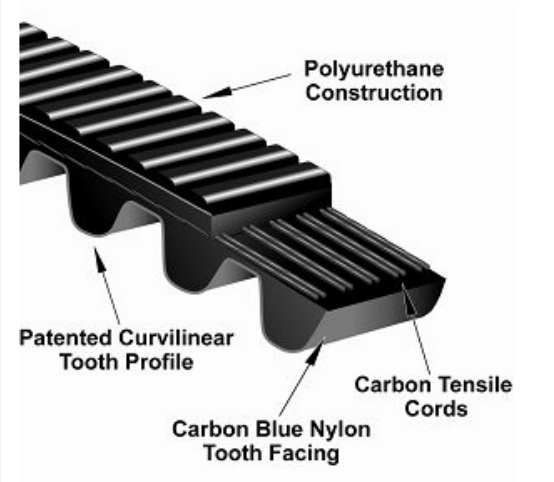
CONCEPTS AND EARLY DESIGN

- Belt Driven
  - Gates Polychain GT2 Carbon 14mm pitch 29mm width
  - 29 tooth sprockets – prime number for reduction in sound
  - Two belts, one to move with suspension, the other rigidly affixed in the skid
- Modified R-Motion Suspension
  - Retain OEM dynamics and track geometry
  - Inverted Triple Link to accommodate belts
  - Redesign of suspension to accommodate belts



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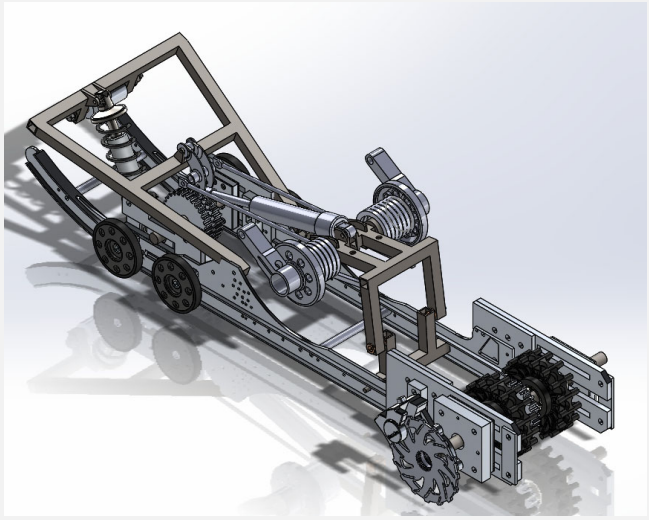
CONCEPTS AND EARLY DESIGN

- Uses 3 axles
  - Front – Intermediate – Rear
  - Locking hubs on drivers in front and rear
  - Brake caliper added to rear axle to prevent back-driving belts
- Use OEM components when possible
  - Replacements designs made with simple materials



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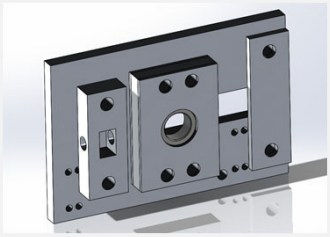
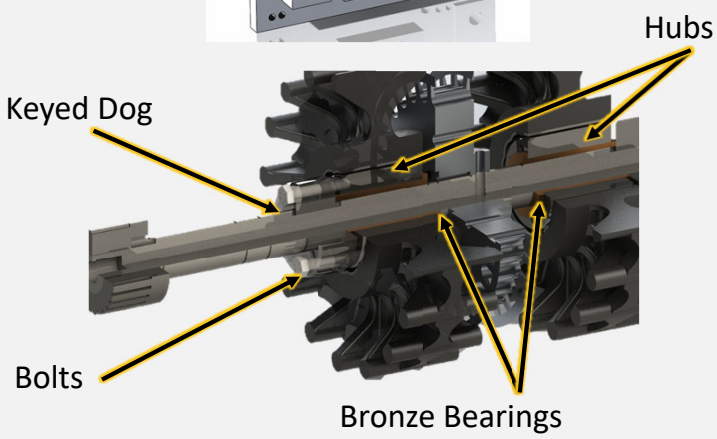
CONCEPTS AND EARLY DESIGN

- Deep groove ball bearings
  - Bears radial and axial loads
  - Use circlips to locate axles



- Bolt locking hubs for drivers
  - Dogs permanently keyed into shafts
  - Hubs float on bearings
  - Engage hubs through the keyed dogs with bolts



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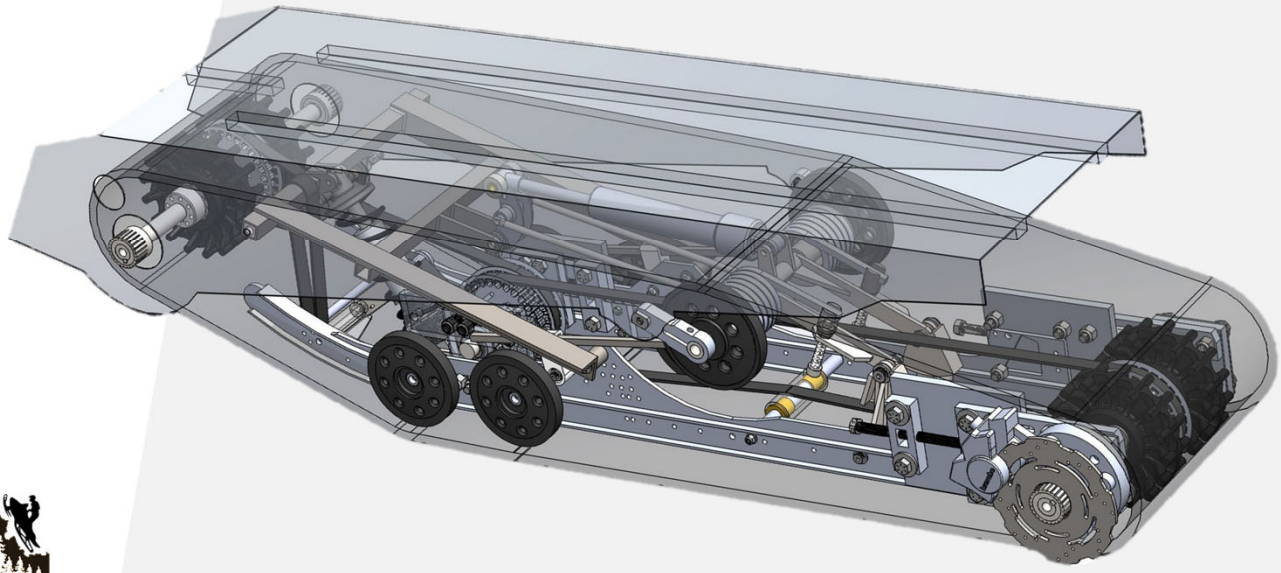
FINAL DESIGN



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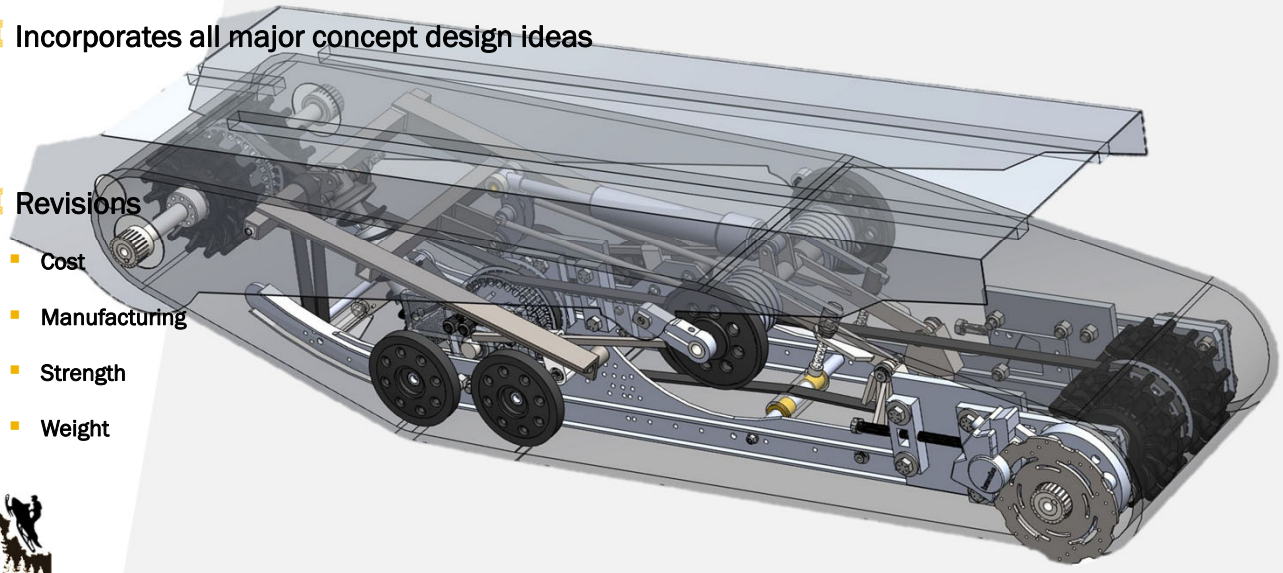
FINAL DESIGN

- Incorporates all major concept design ideas



- Revisions
  - Cost
  - Manufacturing
  - Strength
  - Weight

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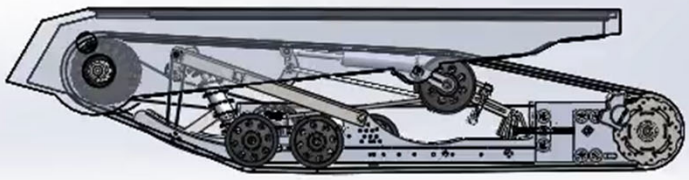
FINAL DESIGN



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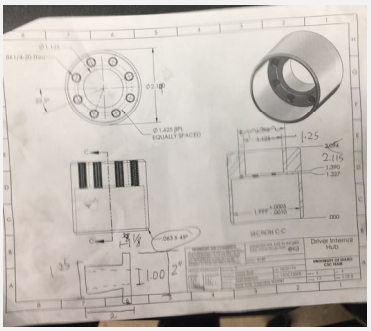
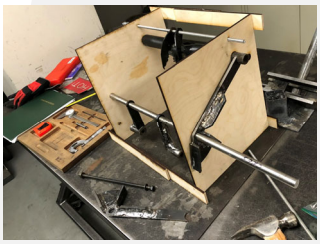
MANUFACTURING

- Manual lathe work
- Manual mill work
- Welding
- Reading, interpreting, and calculating from Polychain patents
- Forced some redesign
- Still needs some finishing





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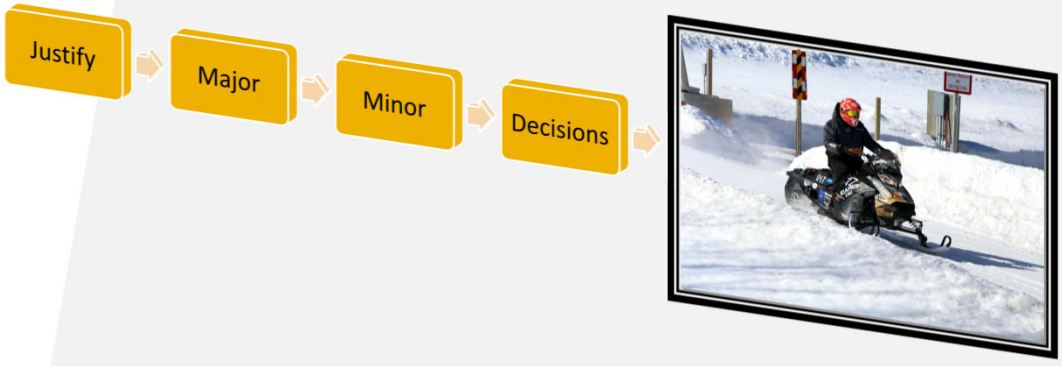
FUTURE VALIDATION PLAN

- Three-part plan
  - Allows failure early
  - Justify → Major → Minor
- Justification:
  - J2263 Coast down to show difference
  - Instantaneous fuel economy
- Major Data Collection:
  - Ride-Average Fuel Economy
  - Durability
- Minor Data Collection:
  - Braking
  - Acceleration



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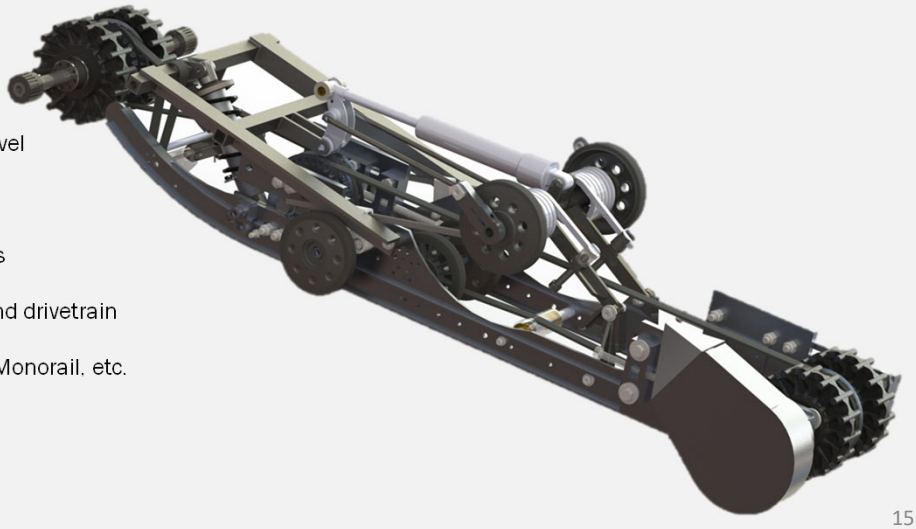
FUTURE RECOMMENDATIONS

- Finish manufacturing according to drawing and CAD package
- Test on Spectre (UICSC 2017 SkiDoo MXZ Snowmobile)
- Future product designs
  - Focus on data driven decisions
  - Redesign front belt to reduce belt travel
  - Use permanent one-piece hubs
  - Use commercial bearing technologies
  - Design around suspension, not around drivetrain
    - C-Motion, T-Motion, Single Beam Monorail, etc.



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THANK YOU TO OUR SPONSORS

Dr. Dan, Dr. Beyerlein, Bill Magnie, Molly Steiner, Chloe Rambo, Alexiss Turner

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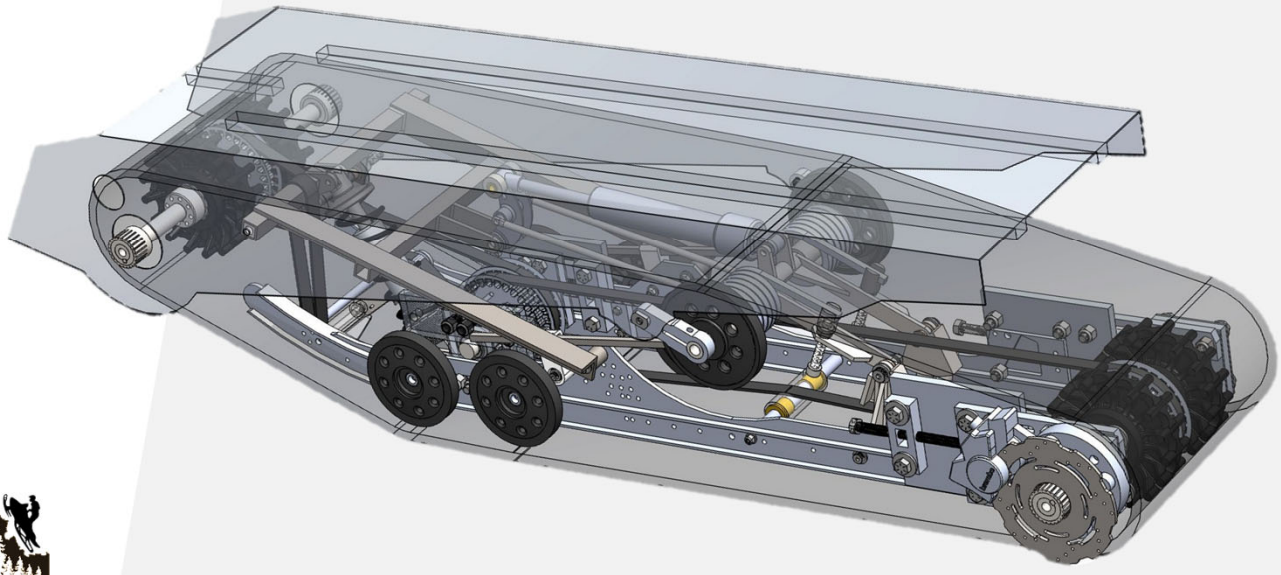
DISCUSSION AND QUESTIONS



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AUXILIARY SLIDES

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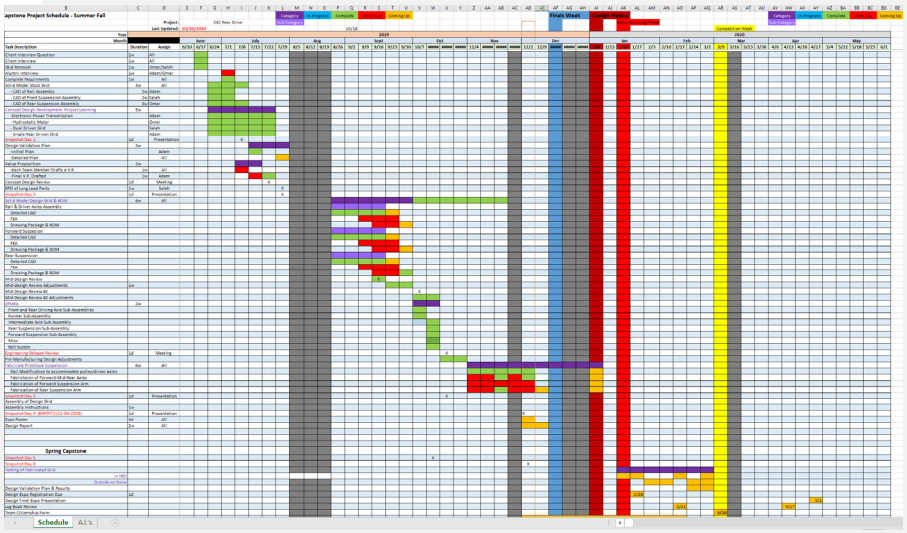
GANTT CHART



CALCULATIONS SPREADSHEET

Pitch	Driver Diameter (IN)	Driver Diameter (FT)	Width	Length	Driver RPM	Driver Teeth	Driven RPM	Driven Teeth	HP	Driven Torque	Tension (lbs)
14	3.859820667	0.321651722	20	2520	3450	22	3300	23	98.8	157.241697	977.714
14	4.035267061	0.336272255	20	2520	3450	23	3450	23	104	158.3211594	941.625
14	9.649551668	0.804129306	20	2520	3450	55	3450	55	290.8	442.6903188	1101.04
14	3.859820667	0.321651722	20	2520	3450	22	3450	22	98.8	150.4051014	935.205 //This shows that the maximum limits are at the smallest diamter with the horsepower, EG the limit is belt tension from driven torque
14	5.087945425	0.423995452	20		3450	29	3450				
14	6.491516577	0.540959715	20		3450	37	3450				
14	6.842409364	0.57020078	20		3450	39	3450				
14			20		3450		3450				

Max Load 1000 LBF (FS=1.8)

//Choose 29 tooth sprocket

1000	0.58 RPM	FT/s	MPH	Horsepower By Sprocket Teeth 22	25	28	29	34	37 Teeth
	0	0	0	0	0	0	0	0	0
	500	15.27	10.412	15.31091595	17.3987681	19.4866203	20.18	23.66232465	25.7502
	1000	30.54	20.825	30.6218319	34.7975362	38.9732406	40.37	47.3246493	51.5004
	1500	45.81	31.237	45.93274785	52.1963044	58.4598609	60.55	70.98697395	77.2505
	2000	61.09	41.65	61.2436638	69.5950725	77.9464812	80.73	94.64929859	103.001
	2500	76.36	52.062	76.55457975	86.9938406	97.43310149	100.9	118.3116232	128.751
	3000	91.63	62.475	91.86549569	104.392609	116.9197218	121.1	141.9739479	154.501
	3500	106.9	72.887	107.1764116	121.791377	136.4063421	141.3	165.6362725	180.251
	4000	122.2	83.3	122.4873276	139.190145	155.8929624	161.5	189.2985972	206.001
	4500	137.4	93.712	137.7982435	156.588913	175.3795827	181.6	212.9609218	231.752
	5000	152.7	104.12	153.1091595	173.987681	194.866203	201.8	236.6232465	257.502
	5500	168	114.54	168.4200754	191.386449	214.3528233	222	260.2855711	283.252
	6000	183.3	124.95	183.7309914	208.785217	233.8394436	242.2	283.9478958	309.002
	6500	198.5	135.36	199.0419073	226.183986	253.3260639	262.4	307.6102204	334.752
	7000	213.8	145.77	214.3528233	243.582754	272.8126842	282.6	331.2725451	360.502
	7500	229.1	156.19	229.6637392	260.981522	292.2993045	302.7	354.9348697	386.253
	8000	244.3	166.6	244.9746552	278.38029	311.7859248	322.9	378.5971944	412.003
	8500	259.6	177.01	260.2855711	295.779058	331.2725451	343.1	402.259519	437.753
	9000	274.9	187.42	275.5964871	313.177826	350.7591654	363.3	425.9218437	463.503
	9500	290.2	197.84	290.907403	330.576594	370.2457857	383.5	449.5841683	489.253
	10000	305.4	208.25	306.218319	347.975362	389.732406	403.7	473.246493	515.004

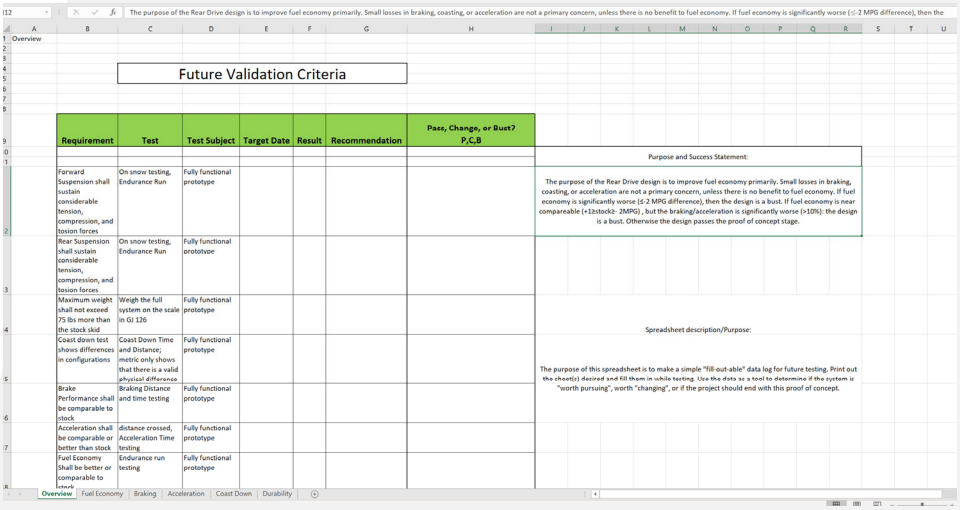
Torque Max (FT-Lbf) 211.997726

520.8333 (Machine Key Torque Limit)

Machine Key Horsepower Transmission

	Circumfrence	Pitch Dia	Center Distances (IN)	(FT)	Availible Belts (GATES PolyChain GT)
49.58429					
99.16857					
148.7529	15.98425	71	39.13386	11.57480315	0.964567
198.3371		80	44.09449	14.05511811	1.17126
247.9214	1190	85	46.85039	15.43307087	1.286089
297.5057	1260	90	49.6063	16.81102362	1.400919
347.09	1400	100	55.11811	19.56692913	1.630577
396.6743	1568	112	61.73228	22.87401575	1.906168
446.2586	1610	115	63.38583	23.7007874	1.975066
495.8429	1750	125	68.89764	26.45669291	2.204724
545.4271	1890	135	74.40945	29.21259843	2.434383
595.0114	1960	140	77.16535	30.59055118	2.549213
644.5957	2100	150	82.67717	33.34645669	2.778871
694.18	2240	160	88.18898	36.1023622	3.00853
743.7643	2310	165	90.94488	37.48031496	3.12336
793.3486	2380	170	93.70079	38.85826772	3.238189
842.9329	2450	175	96.45669	40.23622047	3.353018
892.5171	2520	180	99.2126	41.61417323	3.467848
942.1014	2590	185	101.9685	42.99212598	3.582677
991.6857		190	104.7244	44.37007874	3.697507
		200	110.2362	47.12598425	3.927165
		224	123.4646	53.74015748	4.478346
		236	130.0787	57.04724409	4.753937
		240	132.2835	58.1496063	4.845801
		250	137.7953	60.90551181	5.075459
		275	151.5748	67.79527559	5.649606
		280	154.3307	69.17322835	5.764436
		309	170.315	77.16535433	6.430446
		315	173.622	78.81889764	6.568241

VALIDATION SPREADSHEET



Future Validation Criteria

Requirement	Test	Test Subject	Target Date	Result	Recommendation	Pass, Change, or Bust? P,C,B
Forward Suspension shall sustain considerable tension, compression, and tosion forces	On snow testing, Endurance Run	Fully functional prototype				
Rear Suspension shall sustain considerable tension, compression, and tosion forces	On snow testing, Endurance Run	Fully functional prototvoe				
Maximum weight shall not exceed 75 lbs more than the stock skid	Weigh the full system on the scale in GJ 126	Fully functional prototype				
Coast down test shows differences in configurations	Coast Down Time and Distance; metric only shows that there is a valid physical difference	Fully functional prototype				
Brake Performance shall be comparable to stock	Braking Distance and time testing	Fully functional prototype				
Acceleration shall be comparable or better than stock	distance crossed, Acceleration Time testing	Fully functional prototype				
Fuel Economy Shall be better or comparable to	Endurance run testing	Fully functional prototype				

Purpose and Success Statement:

The purpose of the Rear Drive design is to improve fuel economy primarily. Small losses in braking, coasting, or acceleration are not a primary concern, unless there is no benefit to fuel economy. If fuel economy is significantly worse (≤-2 MPG difference), then the design is a bust. If fuel economy is near compareable (+1stock- 2MPG) , but the braking/acceleration is significantly worse (>10%): the design is a bust. Otherwise the design passes the proof of concept stage.

Spreadsheet description/Purpose:

The purpose of this spreadsheet is to make a simple "fill-out-able" data log for future testing. Print out the sheet(s) desired and fill them in while testing. Use the data as a tool to determine if the system is "worth pursuing", worth "changing", or if the project should end with this proof of concept.

BUDGET

Supplies/Parts	Supplier	Total Cost	Purchased/Needed
½" Sheet Aluminum	Facilities	$ 696.99	Purchased
Angle Iron	Facilities	$ 126.54	Purchased
Steel 4140	Facilities	$ 23.98	Purchased
Belts (4)	Denniskirk	$ 835.00	Purchased
Silent Drive Axles (2)	Valley Powersports	$ 594.00	Purchased
Ski-doo Runners (2)	Valley Powersports	$ 620.00	Purchased
Hardware Order	McMaster-Carr	$ 281.39	Purchased
Hardware Order	Bolt Depot	$ 192.53	Purchased
Brake Line Parts	Amazon	$ 218.98	Needed
5" Round Stock W: 1ft	Metals Depot	$ 171.56	Needed
Bronze Bushings	Moscow Building Supply	$ 20.00	Needed
TOTAL COSTS (ESTIMATED AND FINALS)		$ 3,780.97	Budget ($ 3,750)

REMAINING MANUFACTURING

Parts Remaining:
Front Swingarm
Belt Sprockets
Tensioner Blocks
Front Belt Tensioner
Finish welds and paint
Brake Components
Front Axle
Shaft Inserts